# Mathematical Study Without Pen and Paper: Experiences, Impacts and Options

Wednesday 20th March 2013, Manchester Metropolitan University

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Mary McAlinden of the Higher Education Academy (HEA) gave a short introduction to the day and the relevant work of the HEA. Three 45 minute presentations captured a range of approaches to and experiences of mathematical study without pen and paper. Participants then discussed the scenarios in the context of their various roles and institutions with an aim to reporting back to the room on 'missing' advice sources, specific practice recommendations, services, communication routes or research which they felt needed to be addressed. Below the presentations are summarised and key points of the discussion noted. For full notes on the discussion, further information on the resources mentioned and references please see accompanying documents.

## Capturing, writing and reading maths electronically – what works?

Abi James (University of Southampton and the British Dyslexia Association) gave an overview of mainstream hardware and software currently available for the electronic capture, writing and reading of mathematics. Abi first considered the reasons a student or member of staff may work without pen and paper, distinguishing between difficulties with producing handwritten text and the need to create resources which can be manipulated or interacted with in an accessible manner. Abi noted four chief methods of capturing information – text, video, audio and speech – and presented technologies which used some mixture of these modes. While audio alone is unlikely to be sufficient for full capture of scientific information it was demonstrated that it is possible to use audio to mitigate difficulties with text capture or to enhance what can be captured. For students able to capture some text but who need editing, searching and some audio enhancement tablets and other hardware/software now enable a variety of flexible approaches. However, while some incorporate hand-writing recognition it was demonstrated that mathematical text recognition continues to be very difficult to use. A brief overview of the options for producing equations via keyboard or speech was given. Finally, Abi highlighted that the only currently accessible E-book format for mathematical books is ePub3 with MathML support noting that it is best to request this format from publishers.

## Creating and editing mathematical content using natural language commands – A progress report of the TalkMaths project

Eckhard Pflügel (Kingston University) reported on progress towards creating and editing mathematical content using natural language commands in the TalkMaths Project. Eckhard gave the core objective of the TalkMaths Project as being to carry out research and development leading to a user-friendly system for accessing mathematical content using speech. Eckhard noted known literature on standards for spoken mathematics and gave a brief overview of speech recognition technologies relevant to creation of mathematical text or programming code. By noting the limitations of the available products he concluded that none of the existing tools are fit for purpose. Eckhard outlined the main technical and research challenges involved in the creation of TalkMaths which include tools and techniques from natural language processing, compiler construction and human-computer interaction. He then outlined the steps taken in the development of TalkMaths thus far and the key insight that spoken mathematics “*can and should*” be processed similarly to spoken structured content such as mark-up languages for programming code. Finally, Eckhard summarised the main ways the TalkMaths Project can assist with access to mathematics before reporting on the project progress and directions for future work.

## Supporting mathematical study without pen and paper: some scenarios for discussion

Emma Cliffe (University of Bath) introduced five scenarios in which students may require support in accessing mathematical study without pen and paper. She illustrated this with demonstrations of a small collection of less well known software which might be relevant in these scenarios. The scenarios presented for consideration included: a blind student; a student with severe arthritis in their hands; a student with a severe anxiety disorder which impacted on effective interaction with handwritten text; a dyslexic student with significant handwriting difficulties and a student with a mild visual impairment. In each scenario brief information was given on the student's experiences. Possible options in the scenario, including high and low technologies and human support were presented. The options listed were not exhaustive but further references were included to a wider variety of options in similar scenarios. Emma included demonstrations of both specialist commercial mathematical software and ad hoc, research output or open source software. It was noted that these two categories of software may not be provided or recommended via a student's study needs assessment because they are not well known, they are difficult to train or support for none specialists or due to the concerns regarding their stability or longevity. However, they may be the only viable software solution.

### Discussion

Emma Cliffe took notes on feedback from this discussion – please refer to this accompanying document for full information. The feedback reinforces previously reported requirements for a mathematics specific accessibility knowledge base and for sustainable tools which fill known gaps. Multiple groups independently raised rather more subtle points of particular interest:

* there is a need for work which will facilitate inter-professional collaboration and engagement between subject specialists, disability practitioners and assistive technologists when they are working to support a student;
* there is a need for reward and recognition to motivate and raise the profile of work in access to mathematical study.